RoboCupRescue2006 - Robot League Team Aryaak (Iran)

[1]Hani Moghaddam, [2]Payam Porkar Rezaeiye, [3]Midia Reshadi, [4]Mohammad Shayeganfar, [5]S. Shervin Ostadzadeh, [6] Seyed Behzad Ejlali, [7]Farhad Safavi, [8] Seyed Mojtaba Mortazavinejad

[2,4]Artificial Intelligence & Robotic Engineering Department
[1,3] Computer Architecture Engineering Department
[5] Computer Software Engineering Department
[6] Mechanical Engineering (Design of Solids) Department
[7,8] Mechanical Engineering (Manufacturing & Production) Department

[1,2,3,4,5]Azad University Science & Research Branch

Poonak Sq. Ashrafi Esfehani Blv, Hesarak, Tehran, Iran

[6,7,8]Azad university of Tehran Central Branch

Vali-e-asr complex, Damavand Ave.

www.Aryaak.com
Rescue@Aryaak.com
[1] h.moghaddam@yahoo.com [2] payam_porkar@yahoo.com [3]midia_r_272@yahoo.com
[4] shayganfar_m@yahoo.com [5] ostadzadeh@sr.iau.ac.ir
[6] b_ejlali@yahoo.com [7] farhad.safavi@yahoo.com [8] mortazavinejad@yahoo.com

Abstract. This document describes the "Aryaak "entry into the 2006 Robocup Rescue competition. Team robot name is Mantis. The Robot are equipped with a range of state of the art sensors for mapping, localization and victim identification, and are capable of navigating and autonomously mapping unknown environments, detecting and locating human victims, and identifying the victim states. In this robot exist very important feature for example fast speed cause motor type and mechanical design also all sensors in robot is significant for all detection and identification.

Introduction

Aryaak is a team representing the integration of all students in Azad University from AI department and computer department and mechanical department. All member in this team is the MS graduation or under graduation.

The robot team name is Mantis and consist the very useful feature in mechanical design and other sections. Team worked hard on autonomously section but it requires the lot of time to achieve this goal in future.

Also Mantis has many sensors for victim identification and map generating and used the LASER range-finder, for this purpose. For navigate and victim detection used the network camera. This camera has many useful application and many feature and robot used all of them.

1. Team Members and Their Contributions

In the table that bellows you can see details of all Aryaak members' roles.

Team Leader:	Hani Moghaddam
AI & Map Generation:	Payam Porkar Rezaeiye
Hardware & Electronic Developer:	Hani Moghaddam & Midia Reshadi & Mohammad Shayeganfar
Mechanical Designer & Developer:	Seyed Behzad Ejlali
Mechanical Developer:	Farhad Safavi
Mechanical Constructer:	Seyed Mojtaba Mortazavinejad
Software & GUI Designer:	S. Shervin Ostadzadeh
Team Mentor:	Prof. Habibnejad Korayem

2. Operator Station Set-up and Break-Down (10 minutes)

The Mantis robot will be fully operated via the pictured remote control station, or a wireless enabled laptop. The operator station can be fully setup within three minutes.

3. Communications

We use Wireless LAN in the 5GHz range according to IEEE 802.11A for the communication with the robot. The power is limited to 50mW.

Rescue Robot League		
Aryaak (Iran)		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	52 / 54 Mbps	50
2.4 GHz - 802.11b/g	N / A	N / A
2.4 GHz – Bluetooth	N / A	N / A

4. Control Method and Human-Robot Interface

Mantis robot used the joystick for controlling in unknown environment but tried to robot autonomous. Notice for these years Mantis robot is partial autonomy and full autonomy expected for future. We have used C++ language for all control software modules and also we have implemented the camera controlling software with C++ language. Software including two parts of Video Capturing and also functionality control of the camera. The first part uses a dedicated ActiveX which properly is used to preview captured video streams. Second part helps to implement a bi-directional connection between operator and the camera. It means that the operator can control existent capabilities like Pan, Tilt and zoom, also some other image features like its white-balance, color-level, and transferring image compression beside any other features that can help to a better quality of control. This part is implemented as a win32 dll file which includes all the camera capabilities each with a proper function. The sample of control panel of GUI showed in Figure 4-1.

Figure 4-1: Graphical User Interface Panel

5. Map generation/printing

5-1. Stereo Vision:

Vision method at first was used for estimating robot errors more than one decade ago. So far, different companies and research centers have used for robot positioning, calibration, error estimation and error compensation with genetic algorithm, neural networks and fuzzy control algorithms. In general, recognition of 3D object requires two or more appropriately defined 2D images. With this approximation many methods have been proposed.

On the basis of structure from motion [1-2], stereo lenses are corresponded and illustrated in [3-4]. Achour and Benkhelif presented a new approach for 3D scene reconstruction based on projective geometry without camera calibration. The contribution is to reduce the number of reference points to four points by exploiting some geometrical shapes contained in the scene [5]. In online application, these methods have some problems. There is a difficulty in finding the correspondence between one image and the others. One of these methods is stereo vision. The most important step in stereo vision is to find two points of two or more images. A general approach is to be correlation that has some errors as discussed in [6]. In this paper we applied a fuzzy approach to reduce these errors. Since fuzzy logic has applied in some domains such as process control, decision support system, optimization and a large class of robotic manipulators and other mechanical systems [7]. Here is concerned with the aspect of improving correlation based stereo vision by reducing errors with a fuzzy system on a set of points. The experiments will be on Aryaak robot. So far a neural network approach has been used to get the optimum point in world coordinate for this robot [8]. Clearly there is no magic panacea for selecting a neural network for the best generalization, and also because of structure and foundation of neural networks, it has some errors. A fuzzy approach can be used to reduce these errors.

5-2. Representation of 2D maps with LASER scanner [12]:

The Robocup rescue arena is a generally static environment So got the best 2dimentional map with laser range finder is easy but in this approach exist many different way for produce the environment mapping and we research on this subject until go to goal of Robocup. The map generation sample of assumed environment has been illustrated if Figure 5-2-1.

Figure 5-2-1. The sample of map generation (The green pointer is showing trajectory)

6. Sensors for Navigation and Localization

In order to navigate the robot by the operator, our robot is equipped a network camera and LASER scanner. A network camera can be described as a camera and computer combined in one unit. It captures and transmits live images directly over an IP network, enabling authorized users to locally or remotely view, store, and manage video over standard IP-based network infrastructure. A network camera has its own IP address. It is connected to the network and has a built-in web server, FTP server, FTP client, e-mail client, alarm management, programmability, and much more. A network camera does not need to be connected to a PC; it operates independently and can be placed wherever there is an IP network connection. A Web camera, on the other hand, requires connection to a PC via a USB or IEEE1394 port and a PC to operate. The camera is fixed on the camera platforms (2 degree of freedom). The main components of network camera is illustrated in Figure 6.1.For collecting more information from environment of the robot and generating a better view of environment, we use LASER scanner .The LASER scanner generating the 2D map for representing the position of victims in the final map(The sample of map generation is prepared in section 5) .Other devices which are used in our robot are the gyroscope and encoder .A gyroscope correction system adjusts variation in terrain that characterize disaster situation. The encoder is one of most important part for map generation. The encoder data is combined with LASER data and gyroscope data for map generation.

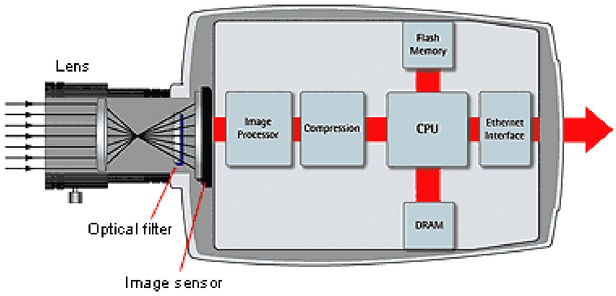

Figure 6.1. The Block Diagram of Network Camera

7. Sensors for Victim Identification

For localizing and identifying victims, we use camera which is fixed on the camera platform and the video feed one streamed to the operator interface. Furthermore our camera is equipped with microphone to detect human voices. To gain more possibilities for victim identification we use infrared camera and temperature and CO2 sensors. The digital RS-232 temperature sensor measures temperature in the maximum distance of 4 meters. The CO2 detectors measures in part per millions of carbon dioxide in the air. We use CO2 sensor which can measures the concentration of CO2 gas in the range of 350-100,000 ppm.

8. Robot Locomotion

8-1.Locomotion type:

Motion of this robot is made by eight wheels that these wheels repose in two rows. Motions of these wheels are provided by eight motors which located in every one wheel [11]. This mechanism allowed to line motion's wheels that static and also becoming motion revolve. Our robot is illustrated in Figure 8-1-1.

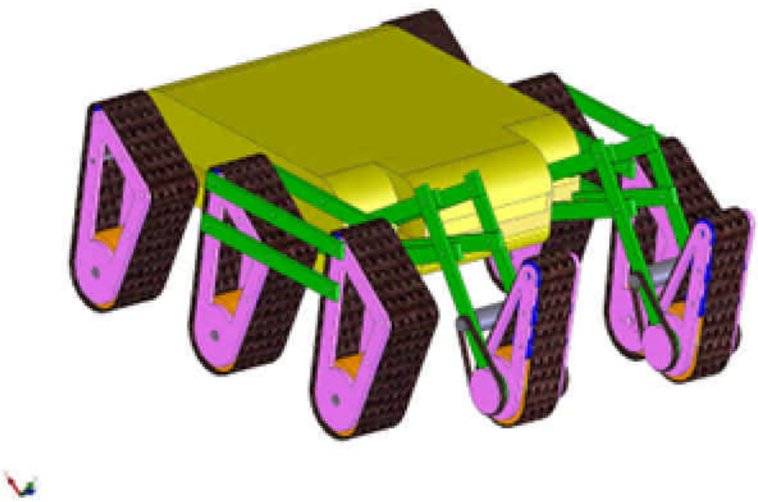

Figure 8-1-1. First situation of Mantis robot

8-2.Front wheel mechanism priority: [8, 9, 10]

Front wheel mechanism that has been used is in this way if front wheel encounter with vertical obstacle could ascendant automatically therefore obstacle. Highlight is this mechanism doesn’t used of any sensor corresponding angle measurement pressure measurement and other sensor.[13,14] This feature just cause included motion mechanism type and is the basic advantage in use of this mechanism. This mechanism illustrated in Figures 8-2.a & 8-2.b.

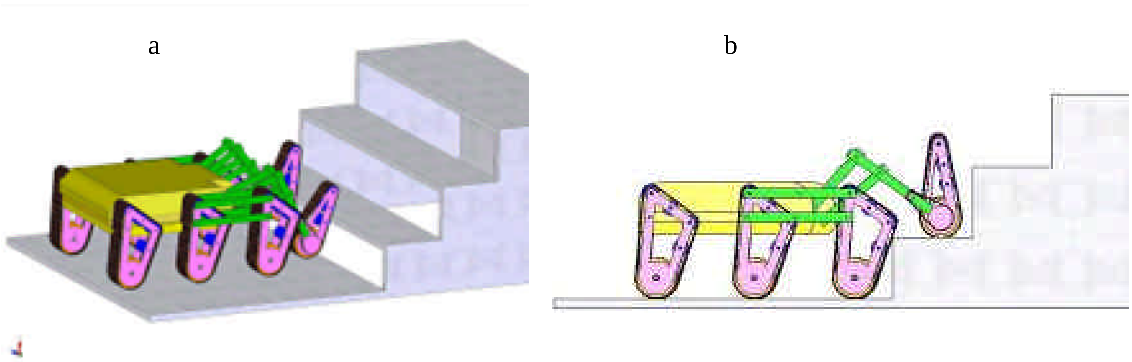

Figure 8-2-a: Robot is climbing stair b: The front wheels are on the first stair

8.3. Beside wheels mechanism priority: [8, 9, 10]

Beside wheels provided this advantage which the obstacle is bigger than diameter wheels. It is possible for wheels that revolve around two joint and relocate then they could passed from obstacle about twice of diameter wheels. In fact there are six wheels in this mechanism which could have up-down motion and help robot for passed the obstacle. The mechanism is illustrated in Figure 8-3.a & 8-3.b.

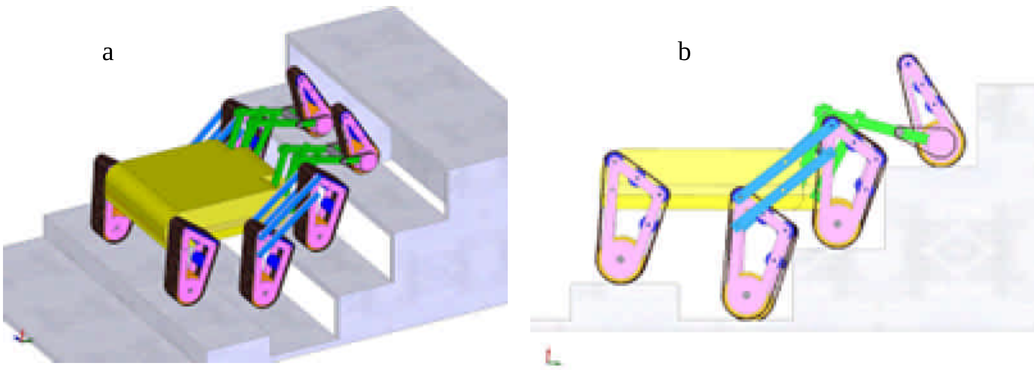

Figure 8-3.a. Dimetric view orientation b. right view orientation

8-4.Camera motion mechanism:

In this structure arm designed that except the motion of camera around prime axis and revolve provide possible up-down motion for camera. Thereby in this mechanism provide motion width about 1.2m. For less bending torque to camera motive motor initiate used with two mechanisms and with one motor can controlled and adjusting location of camera.

8-5.Ability of changing form:

This robot also has ability that during necessary change formed and conversion to complete tracked robot. In this robot also added two tracked arms [15] until during time of changing form used favorable operating for passed from obstacle especially for pass of induction steps. Foregoing robot even if don't used changing form feature against Shrimp robot had a limited ability that ascending from this obstacle.

For this reason has been angled beside wheels belts during tracked state get the convenience motion and passed from obstacle. For changing form just has been used from two motors so toward alive design is more advantage and summary than other and manner changing form doing with two motors. The second situation of robot illustrated in Figure 8-5-1.

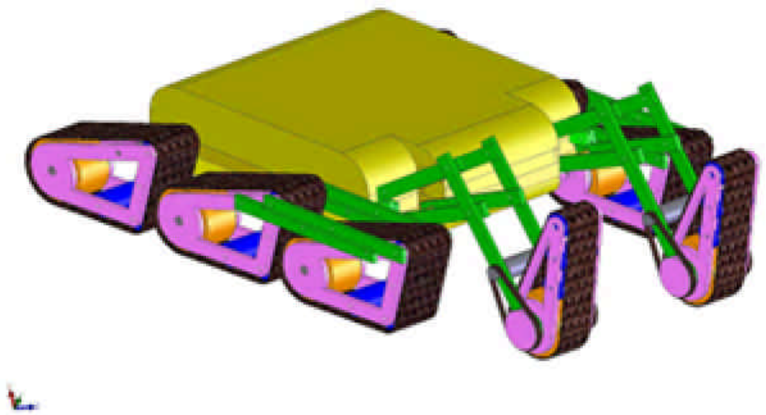

Figure 8-5-1. Second Situation of Mantis robot

8-6.Measure and primary design:[11]

In this robot has been used from tracked motion for revolving. Noticed relationship between length and width of repose limiting is allowable. Robot could take 35kg weight with 50cm/s speed. Of course this ability is during that robot motion from rest state to maximum speed in standard condition. Also in passed of obstacle and ascending from step this robot could until descent 35 degree and step with 23cm height and speed for ascending from step with same weight is 0.3m/s. maximum speed in this robot is 0.7m/s in flat surface with 35kg weight also notice this weight include robot weight. In this robot used belt for power transmission and this ability cause to make smooth motion and increased performance. In passed from obstacle also ratio other mechanism power transmission than better and motion is very easy.

Also robot natural frequency achieved with ADAMS 2005 software (Robot simulation has been showed in www.Aryaak.com) and tried to robot design until alternation period (T) minimum measure. In this case (minimum alternation period) ? is system natural frequency that take from ? T=2*p* formula. In this formula with increase ? decrease T and decrease T provided situation and in this situation bumping in robot decrease more (bumping weight make during force less than 1/3 natural alternation period. They tried to decrease adjustment concern by increase pieces mass and distribution adjustment based continuous adjustment lines. Surface is thin and inhibition of 3dimentional adjustment and inhibition from break incompetent fission pieces. Simulation in ADAMS 2005 has been illustrated in Figures 8-6-1, 8-6-2, 8-6-3, 8-6-4 and 8-6-5.

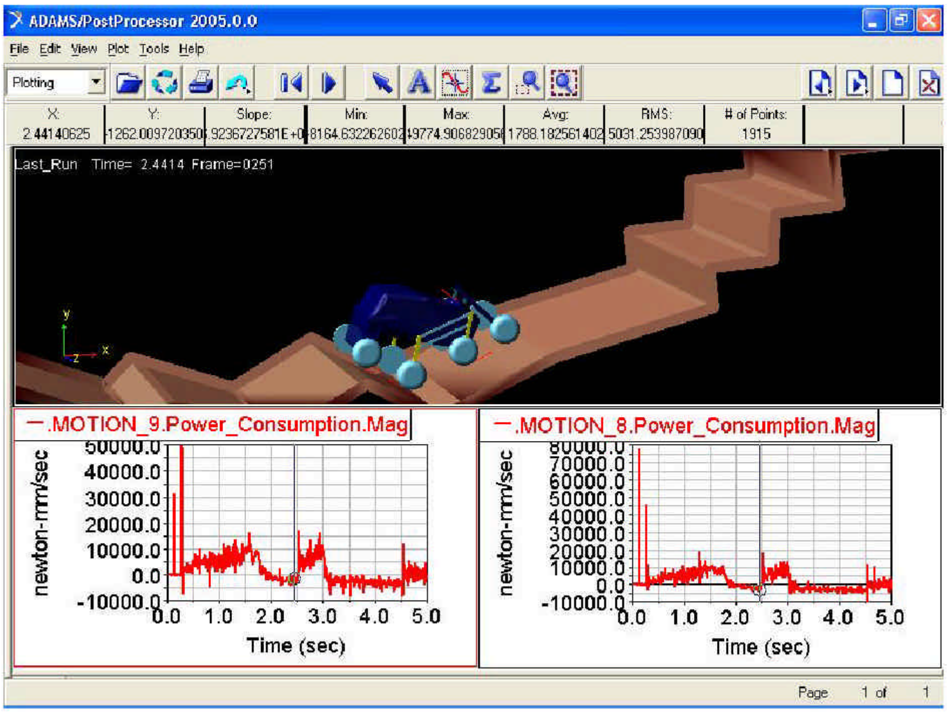

Figure 8-6-1. Simulation of robot ADAMS 2005

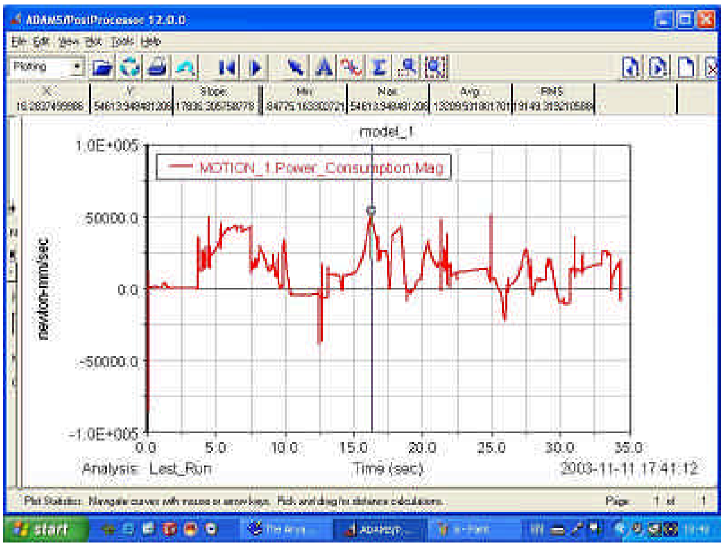

Figure 8-6-2. Power consumption plot of front wheels by ADAMS

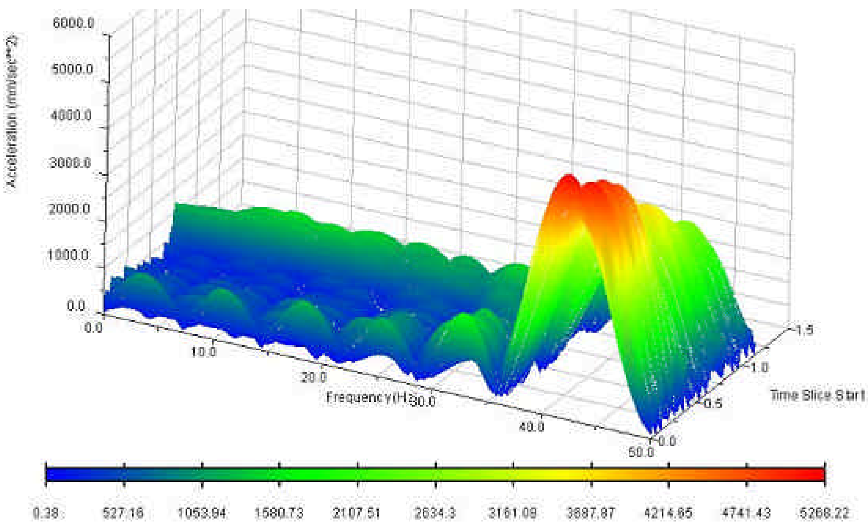

Figure 8-6-3. Sample of FFT plot for acceleration toward Y axis chassis

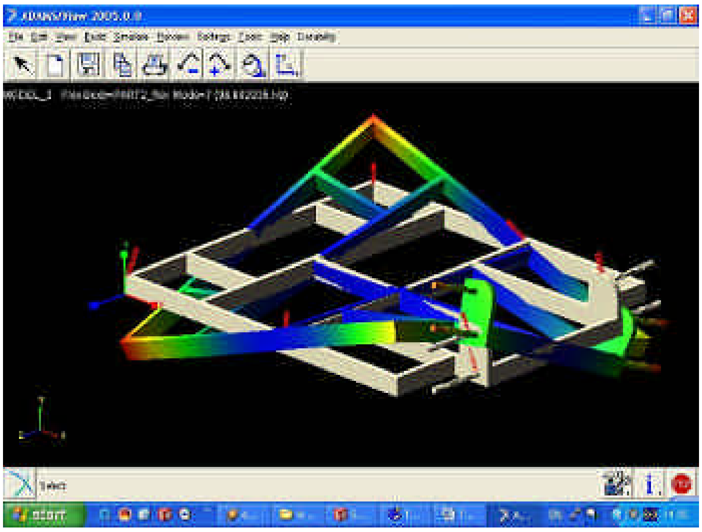

Figure 8-6-4. Mode7 of chassis taking from ADAMS2005 software

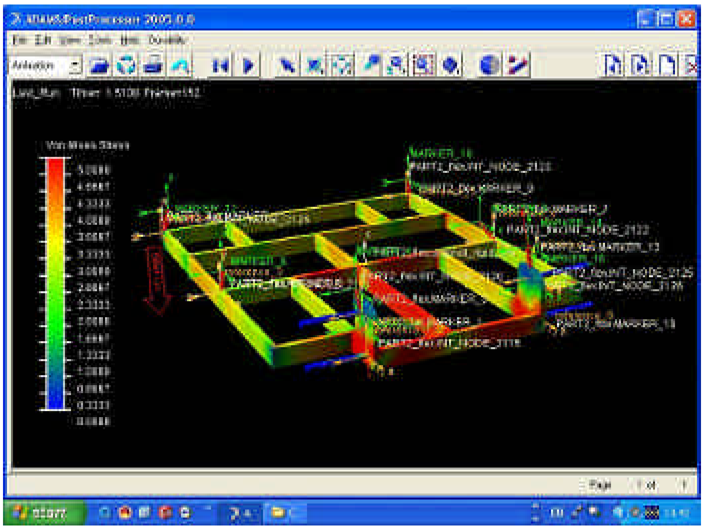

Figure 8-6-5 Sample of Stress analysis from chassis under oscillation load

8-7.Robot simulation:

Models of robot and portions simulated on Solidworks2006 software and analyzed primary adjustment in Cosmos environment in Solidworks2006 environment active is doing. This models export to ADAMS 2005 for dynamic analyzed and optimization of all pieces include link length, diameter wheels and dimension used from this software. Also selected power, motors gearbox and output Rpm used from this software.

Primarily by planning made in ADAMS 2005 completed original models in Solidworks2006 and created construction map and used functional then by used from functional results and also by used from experimental charts and by used of power tools in ADAMS 2005 environment their compare with virtual results then got the best optimization and final result is functional. Modeling of robot is illustrated in Figure 8-7-1and 8-7-2.

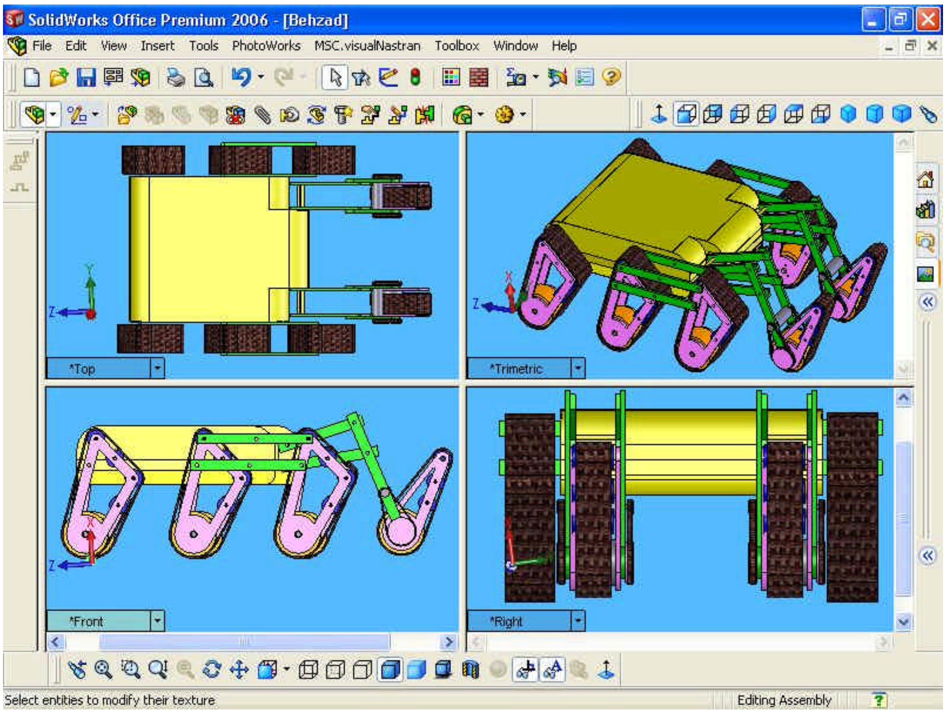

Figure 8-7-1. Modeling first situation of robot in Solidworks 2006 software

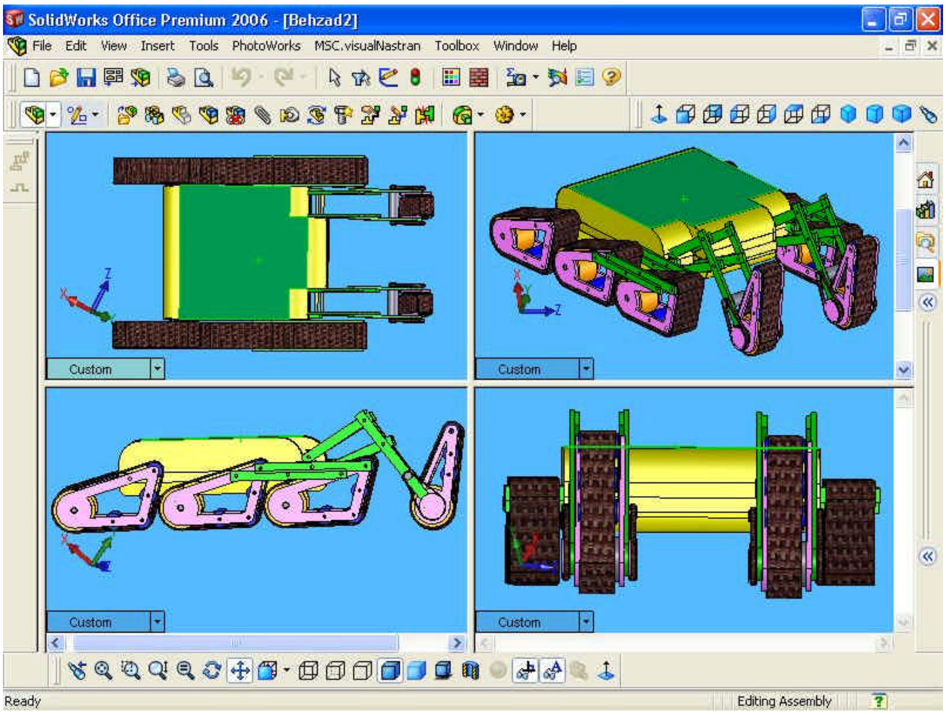

Figure 8-7-2. Molding second situation of robot in Solidworks 2006 software

Also the primarily sample of Mantis robot has been made and testing for performance of mechanism in environment. The final Mantis robot with all state of the art sensors is making and completed soon. It has been illustrated in Figure 8-7-3.

Figure 8-7-3. The primary sample of Mantis robot

9. Team Training for Operation (Human Factors)

All members of Aryaak team have a many experience in robotics and three members of team participating in Robocup Portugal 2004 and Robocup Osaka 2005. also further of members study MS in Azad university and have many article in robotics.

10. Possibility for Practical Application to Real Disaster Site

The Mantis robot has been designed for very complex environments and real disaster sites since mechanic mechanisms have been designed with variety types. Mantis robot could work in variety situations for example flat state and standing state. Mechanism of robot helps up down climbing easily. Victim detection sensors of Mantis robot have ability for victim detects even under wreckages. Mantis map generation systems capability for provided good mapping of unknown environment applicably. This map produced by there mechanisms which one of them generation with laser range finder and two mechanism generation with encoders and gyroscope and there mechanism for this purpose provide by stereo vision system and final result map generating combined from this there mechanism and gave the best map form them.

11. System Cost

TOTAL SYSTEM COST: approx. $25,000
See website: www.Aryaak.com

KEY PART NAME: Infrared camera
MANUFACTURER: Flir Systems
COST: 10.000,- €
WEBSITE: http://www.flir.com/
DESCRIPTION/TIPS: Enable the robot to detect body heat.

KEY PART NAME: Carbon Dioxide Sensor
MANUFACTURER: Telaire
COST: 350,- €
WEBSITE: http://www.telaire.com/
DESCRIPTION/TIPS: Detect victims “breath”.

KEY PART NAME: LASER infrared Temperature Sensor
MANUFACTURER: mikron
COST: 400 €
WEBSITE: http://www.mikroninfrared.com/
DESCRIPTION/TIPS: measures the temperature of robot environment

KEY PART NAME: Gyro Correction System
MANUFACTURER: ActivMedia
COST: $280
WEBSITE: activmedia.com

KEY PART NAME: Laser Mapping and Navigation AT
MANUFACTURER: ActivMedia
COST: $7,495
WEBSITE: activmedia.com

KEY PART NAME: Laptop PC
PART NUMBER: Precision M60
MANUFACTURER: Dell Inc.
COST: US$4,000.
WEBSITE: http://www.dell.com/

KEY PART NAME: Wireless 802.11 a/b/g access point (3COM OfficeConnect 3CRWE454A72)
PART NUMBER: 1
MANUFACTURER: 3COM
COST: 180€
WEBSITE: www.3com.com
DESCRIPTION/TIPS: Three band wireless access point. It works in master, client

References

[1] Seitz, S. M., and Dyer, C. R., "Complete Scene Structure from Four Point Correspondences", 5th Int. Conf on Computer Vision, Cambridge MA, 1995, pp.330-337.

[2] Taylor, C. J., and Kriegman, D. J., "Structure and Motion from Line Segments in Multiple Images", IEEE Trans. on Pattern Analysis Machine Intelligence, Vol.17, No.11, 1995, pp.1021-1033.

[3] Haralick, R. M., and Shapiro, L. G., "Computer and Robot Vision", Addison-Wesley Pub, 1992.

[4] Grosso, E., Metta, G., Oddera, A., and Sandini, G., "Robust Visual Serving in 3-D Reaching Tasks", IEEE Trans on Robotics Automation, Vol.12, No.8,1996, pp.732-742.

[5] Achour, K., and Benkhelif, M., "A New Approach to 3D Reconstruction without Camera Calibration", Pattern Recognition, Vol.34, No.12, 2001, pp.2467-2476.

[6] Lopez, A., and Plat, F., "Dealing with Segmentation Errors in Region-Based Stereo Matching", Pattern Recognition, Vol.33, No.8, 2000, pp.1325- 1338.

[7] Hsu, Y., Chen, G., Li, H., "A Fuzzy Adaptive Variable Structure Controller with Applications to Robot Manipulators", IEEE Transaction Systems man and Cybernetics part, Vol. 31, No.3, 2001, pp. 331-340.

[8].A.F D'souza, V.K. Garg, "Advanced Dynamics Modeling and Analysis ", Prentice Hall Inc, 1984.

[9]. A.H. Soni, "Mechanism Criticize and Analysis ", Scripta Book Comp, 1974.

[10]. J.T. Kimbrell, "Kinematics Analysis and Criticize" McGraw Hill Inc, 1991.

[11] Michaud S., Schneider A., Bertrand R., Lamon P., Siegwart R., et al., " SOLERO: Solar-powered Exploration Rover", Proceedings of the 7th ESA Workshop on Advanced Space Technologies for Robotics and Automation,
The Netherlands, ASTRA2002, 2002.

[12] Lamon P., Siegwart R., "Inertial and 3D-odometry Fusion in Rough Terrain – Towards Real 3D Navigation", IEEE/RSJ International Conference on Intelligent Robots and Systems, Sendai, Japan, 2004.

[13] Iagnemma K., Dubowsky S., "Vehicle Wheel-Ground Contact Angle Estimation:With application to Mobile Robot Traction Control", 7th International Symposium on Advances in Robot Kinematics, ARK '00, 2000.

[14] Lauria M., Piguet Y. and Siegwart R., "Octopus - An Autonomous Wheeled Climbing Robot", In Proceedings of the Fifth International Conference on Climbing and Walking Robots, Published by Professional Engineering Publishing Limited, Bury St Edmunds and London, UK, 2002.

[4] IS Robotics. http://www.isr.com/research/urban.html. 1999.

[15 IS Robotics. http://www.isr.com/research/urban.html? 1999.